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On the Geological Position of Bennettites dacotensis Macbride with Remarks on the Stratigraphy of the Region in Which the Species Was Discovered

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fields of knowledge thus brought to view he has new experiences and new thoughts and is taught the increased importance of application, reasoning and preliminary training. In short we aim to benefit first the student and next the profession by the second kind of experimental work.

The time spent on thesis investigation and writing ranges in amount from one hundred to two hundred hours of actual work.

The scope of the original work in experimental engineering for the past two years is indicated by the following subjects chosen from the whole number assigned:

The force exerted in cutting cast iron, wrought iron and steel in the lathe.—For cast iron the force is proportional to the amount of metal removed. For wrought iron and steel the force does not increase as rapidly as the amount of metal removed.

Determination of the point pressure and twisting moment exerted by twist drills in cast iron, steel and brass.—A collection of data useful in the design of drill presses.

The resistance of swing check valves in the return pipes of steam heating systems.—Found to be very slight, indeed—not over one-quarter of a pound.

Some of those projected for the coming year are:

Friction of cylinder oils.

Variation of stress in the punching of metals.

Variation of economy of the steam engine with change of load.

Experiments with small venturi meters.

In the other departments of the engineering, electrical, civil and mining, the experimental work plays an important part and is prosecuted with vigor by the instructors and students.

Ames, Iowa, December 26, 1893.

ON THE GEOLOGICAL POSITION OF BENNETTITES DACOTENSIS MACBRIDE, WITH REMARKS ON THE STRATIGRAPHY OF THE REGION IN WHICH THE SPECIES WAS DISCOVERED.

BY SAMUEL CALVIN, IOWA CITY.

Since Professor Macbride's paper on *Bennettites dacotensis* was published in the *American Geologist* for October, 1893, there have been numerous inquiries respecting the exact geological horizon from which the cycads were derived. The close resemblance and the intimate relationship indicated between the Dakota fossil and *Tysonia marylandica* Fontaine, while not conclusive, would point toward a common horizon for the two species, and so make it possible to correlate the Potomac formation with a definite Mesozoic horizon in the northwest. Prosessor Macbride's paper left

the stratigraphical position of his species undecided. To settle, if possible, the question definitely, the writer recently made a visit to the locality that furnished the types of Macbride's species.

Specimens of Bennettites are not very numerous in the Black Hills of South Dakota. At all events not very many have yet been brought to light. All the individuals at present known have been found in a rather limited area around Minnekahta, a small station on the Deadwood branch of the B & M. railway. By far the greater number, some forty or fifty altogether, were discovered on an area of only a few acres, about four or five miles southwest of Minnekahta. They all lay partly imbedded in the soil on the southern slope of one of the low, rounded, grassy hills that characterize the marginal portion of the Black Hills uplift. Separating the cycad hill from the next on the south is a comparatively shallow, but steep sided cañon, supporting a moderately dense growth of *Pinus ponderosa* Douglass. The walls of the cañon reveal the edges of gently folded and tilted beds of sandstone. Sandstones—yellow, brown or red, sometimes in massive, and sometimes in thinner layers—often project above the grassy surface on the gentler slopes above the cañon walls; while here and there are high buttes rising two or three hundred feet above the general level, and composed of conformable beds of sandstone throughout their entire elevation. A single sandstone formation therefore, extends from the bottom of the small secondary canyons of the region to the top of the buttes; and, though no cycads were seen in place, there is no reason to doubt that it was in this sandstone, at some level, that they were originally imbedded. The sandstone exhibits the characteristics of the Dakota group of the Black Hills as described by Hayden, Winchell and Newton; still it was thought best not to decide the question of its age on lithological grounds alone. Diligent search during the time at our disposal failed to disclose the remains of recognizable plants or animals belonging to the sandstone in place. Fragments of silicified trunks, probably of deciduous trees, lay loose on the surface. Some of these were mingled with the cycad trunks, and, since the condition of mineralization was the same in both, it was inferred that the silicified trunks of both types had been imbedded under the same conditions, and that they probably came from the same horizon. A short distance east of the cycad field a gray shale, supposed to be the Jurassic of the geologists who have written on the Black Hills, was revealed by an upward arching fold in the bottom of the canyon, but as it contained no fossils judgment was for a time reserved. Three or four miles west of the main group of cycads the ash colored shales, recognized beyond a doubt by *Belemnites densus*, M. and H., and other characteristic fossils as the Black Hills "Jurassic" are exposed in full force in the east side of Big Horn basin. The whole thickness of the Jurassic, two hundred feet or more, is thus revealed; while beneath the Jurassic shales, at the bottom of the basin-like valley, there is an exposure of Red Beds having a thickness of twenty or thirty feet. The rim of Big Horn basin, on the east side at least, exhibits ten or twelve feet of heavy, cross bedded sandstone resting directly on the Jurassic shales. These cross bedded layers constitute the base of the great sandstone formation, to which reference has already been made. The formation extends from the Jurassic shales to the summits of the adjacent buttes. On stratigraphical evidence we are now prepared to recognize it as the Dakota

sandstone. The cycad beds are therefore Cretaceous and belong to Meek and Hayden's Cretaceous No. 1.

A considerable thickness of the sandstone at the top of all the higher buttes of the region has been converted into a very hard, brittle quartzite. The process of vitrification has in some instances almost completely obliterated the original structure; in other cases the original grains are seen imbedded in a a secondary deposit of silica. Contrary to the opinion of some observers, I believe the vitrification to be due to conditions that existed in the sea at the time the beds were deposited. The waters were charged with an unusal amount of soluble silica, which was not only precipitated among the sand grains, converting the whole mass into a homogeneous quartzite, but some of it was substituted for the molecules of wood and other tissues in the stems of cycads and deciduous trees, that by accident were floated in from adjacent lands. The silicified trunks of ordinary trees now found on the lower slopes occupied by the sandstone are very much broken and weathered and polished by long exposure. On the shoulder of one of the buttes a mile or two west of the main cycad field, not far below the level of the vitrified bed, there was noted a silicified log two feet in diameter at the base, twelve feet of the basal part unbroken, with a train of fragments of varying dimensions extending from the smaller end far enough to indicate an original length of seventy or eighty feet The fresh appearance of this specimen, with its fractures all sharp angled and its parts of consid erable length all in their natural relative positions, was in striking contrast with the short, polished, worn, disassociated fragments found in the residual soil on surfaces two or three hundred feet lower. The differences in condition and appearance indicate enormous differences in the length of time the specimens have been exposed. The effects on the better preserved specimen, of rain and frost and wind driven sands, with frequent falls from undermining cliffs, during the years necessary to reduce the hill on which it lies to the level now occupied by the fragments with which it is compared, will not be left to conjecture so long as the worn and dismembered fragments lying at lower levels remain to furnish objective illustrations of what those effects have been in the past. These are reasons for the conclusion that all the silicified trunks, including those of Bennettites, came from the same horizon, and that that horizon was the vitrified beds near the summit of the Dakota sandstone.

East of the valley followed in this vicinity by the B. & M. railway, rises Arnold's peak, a high butte, the summit eight hundred feet above the valley, and like the other high points of the region, capped with vitrified sandstone. The geological structure at the base is concealed, but a mile or two farther north, almost directly east of Minnekahta, the high ridge of which Arnold's peak is simply the most prominent part, reveals at its base the belemnite-bearing beds of the Jurassic. The plain on which Minnekahta stands is some scores of feet below the top of the Jurassic, and not less than six hundred feet below the vitrified sandstone near the summit of the Dakota group. On this plain a few specimens of Bennettites have been found, but in most cases they were so far decomposed as to fall to pieces when attempts were made to remove them. Again we find some relation between the abrasion and decomposition that the fossils have undergone and the vertical distance they lie beneath the level of the vitrified beds. Assuming that all

the fossils were imbedded at essentially the same horizon, then those that now occupy the lowest level have been longest exposed to atmospheric and aqueous agencies.

At Hot Springs, about twenty miles as one has to travel from the principal group of cycads, the valley of Fall river has been cut down through the entire thickness of the Dakota sandstone, through all the Jurassic, and down into the purple limestone and gypsiferous red clays of the Red Beds. Battle Mountain, east of the town of Hot Springs, has an elevation of about a thousand feet above the valley. The upper part of the mountain is composed of the Dakota sandstone, and away up at the summit is the quartzite seen on the higher eminences around Minnekahta. Fall river, formerly known as Minnekahta creek, flows off toward the southeast to join the south fork of the Cheyenne river. About four miles from Hot Springs, the stream emerges from the sandstone hills in a series of cascades which constitute the falls of Fall river. At the falls, as previously observed by Newton, the sandstone is inclined at a high angle and passes beneath the dark colored shales of the Fort Benton group. Crossing the nearly level plain that separates the last of the sandstone hills from a high escarpment that curves around nearly parallel to the margin of the uplift, we find ourselves on calcareous beds of the Niobrara group. These are charged with *Inoceramus problematicus* Schlotheim, with occasional colonies of *Ostrea congesta*, the whole aspect of the formation resembling closely the Inoceramus bearing beds near Sioux City, Iowa, and Ponca, Nebraska. The similarity of the Sioux City deposits to Niobrara beds on French creek, a locality probably thirty miles northeast of the point just noted, was remarked by Prof. N. H. Winchell in 1874.

Over on the Cheyenne river, about six miles east of Fall River Falls, is an exposure of Niobrara that reminds one of the massive chalk beds at St. Helena, Nebraska. The resemblance is not complete, for at St. Helena the beds are for the most part white, only occasionally portions are bluish in color owing to the presence of organic matter. On the Cheyenne the beds are all bluish. They give out a strong fœtid odor when struck with the hammer. There are indications of the presence of organic matter in unusual amount. But the massive bedding of the soft, calcareous material, the manner in which the layers break down, the huge blocks of talus, the occasional small colonies of *Ostrea congesta*, the vertebræ and scales of fishes, are each and all perfectly duplicated at the two points mentioned; namely, on the Missouri at St. Helena, and on the south fork of the Cheyenne southeast of Hot Springs.

Around Edgemont, south of the hills, the country for some distance is occupied by the Fort Benton shales. A steep escarpment which constitutes the vertical face of the first terrace south of Cheyenne, reveals with their usual characteristics, the Inoceramus beds of the Niobrara; but passing on southwest over the hills toward the valley of Cottonwood creek, the Fort Benton is again exposed. Erosion of the shales has formed a series of Bad Lands on a diminutive scale. It has at the same time made prominent certain beds of impure limestone, from which we obtained numerous fossils. Among the collections here were specimens of *Prionocyclus wyomingensis* Meek, *Scaphites warreni*, Meek, *Lunatia concinna* M. and H., *Inoceramus pseudo-mytiloides* Scheil, two or three other species of Inoceramus, a Pteria or two, and many other less obtrusive forms that have not yet been identified.

At the town of Hot Springs some portions of the valley are occupied by horizontal beds of a very coarse conglomerate that lies unconformably on the folded and tilted Red Beds. The thickness of the conglomerate is about forty feet. It is composed of fragments of all the harder formations from the crystalline rocks at the center of the uplift to the purple limestone of the Red Beds and the quartzite of the Cretaceous. When the conglomerate was deposited the valley had essentially its present depth. In some places the streams have just fairly completed the work of cutting through the conglomerate, in other places they have cut twenty or thirty feet below its base. This conglomerate is probably the equivalent of that lying at the base of the White river Miocene. If so it would indicate an enormous amount of erosion between the beginning and middle of the Tertiary as compared with the amount accomplished since.

Returning finally to the main object for which these observations were undertaken, it is clear that *Bennettites dacotensis* Macbride, belongs to the Cretaceous period, and the evidence is practically conclusive that the exact horizon at which the individuals of the species were imbedded is represented by the uppermost layers of the Dakota sandstone.

NOTES ON THE LOWER STRATA OF THE DEVONIAN SERIES IN IOWA.

BY WILLIAM HARMON NORTON.

In a report recently made to the State Geological Survey, the writer communicates in detail some facts regarding the brecciated zone of the Devonian in Linn county, Iowa, and the terranes subjacent. The following is in part a brief summary of this report:

In the breccia which occupies the same horizon from Davenport to Fayette, and which has been termed by McGee the Fayette breccia, four stages are discriminated.

The fourth, or upper stage, involves in Linn county to a greater or less extent several life-zones of the Cedar Valley limestone, including the horizons of *Acervularia davidsoni* (E. and H.), *Phillipsastrea gigas* (Owen), *Spirifera pennata* (Owen), and *Spirifera dimesialis* (Hall). Matrix and fragments are alike being fossiliferous and shaly, and the fragments are usually large and often but slightly disturbed.

The third stage is distinguished by the predominance of fragmental masses, often large and rectangular, of a tough, grey, crystalline or semi-crystalline, heavily bedded limestone, containing a distinct fauna, of which a large *Gyroceras* and *Rhynchonella intermedia* (Barris) are the most characteristic fossils, and *Gypidula occidentalis* (Hall) and *Orthis macfarlandi* (Meek), the most common. The limestone of which these fragments is composed is not found in place in Linn county.